

Thermodynamics — CBSE Pattern Test 1

Class 11 Physics · 90 minutes · 40 marks · Sections A–D with answer key · Narayan Gurukul Academy

Test 1 — CBSE Pattern (90 minutes, 40 marks)

Class 11 Physics · Thermodynamics · Narayan Gurukul Academy (ClassApna)

General Instructions: (1) This paper has four sections — Section A (1×10), Section B (2×4), Section C (3×4) and Section D (5×2) — total 40 marks. Time allowed: 90 minutes.

(2) All questions are compulsory. No overall choice is given; internal choice, where allowed, is clearly marked.

(3) For MCQ questions choose the single correct option; for VSA answers write a single line.

(4) Take $g = 10 \text{ m/s}^2$. All symbols carry their usual meaning. Use of a calculator is not permitted.

Section A — MCQ & VSA ($10 \times 1 = 10$ marks)

- Two bodies are in thermal equilibrium when they have
 - the same temperature
 - the same mass
 - the same volume
 - the same pressure
- The zeroth law of thermodynamics is the basis of
 - temperature measurement
 - measurement of volume
 - the first law
 - the second law
- Heat flows between two bodies only when
 - their temperatures differ
 - their masses differ
 - they are made of different materials
 - one is at rest
- Which of the following is a path function?
 - Heat (Q)
 - Internal energy (U)
 - Temperature (T)
 - Pressure (P)
- For an ideal gas, the internal energy depends only on
 - temperature
 - pressure
 - volume
 - mass density
- The work done by a gas expanding at constant pressure P through a volume change ΔV is
 - $P\Delta V$
 - $P/\Delta V$
 - $\Delta V/P$
 - $P\Delta V^2$
- Which of the following is a state function?
 - Internal energy

- (B) Heat
 - (C) Work
 - (D) Path length
8. The first law of thermodynamics is a statement of
- (A) conservation of energy
 - (B) conservation of mass
 - (C) conservation of momentum
 - (D) conservation of charge
9. Define an isothermal process and an adiabatic process.
10. State the second law of thermodynamics (Kelvin–Planck form).

Section B — Short Answer I ($4 \times 2 = 8$ marks)

11. One mole of an ideal gas expands isothermally at 300 K from 2 L to 4 L. Find the work done. ($R = 8.31 \text{ J mol}^{-1} \text{ K}^{-1}$)
12. In a cyclic process, the heat absorbed is 400 J and the work done by the gas is 400 J. Find the change in internal energy.
13. For an ideal gas, $C_p = 29 \text{ J/mol K}$ and $C_v = 21 \text{ J/mol K}$. Find the gas constant R .
14. A gas expands from 2 m^3 to 5 m^3 at a constant pressure of $4 \times 10^5 \text{ Pa}$. Find the work done by the gas.

Section C — Short Answer II ($4 \times 3 = 12$ marks)

15. Derive the relation between C_p and C_v for an ideal gas.
16. Describe the Carnot cycle with a p – V diagram and derive the expression for its efficiency.
17. A gas is expanded adiabatically from a pressure of $2 \times 10^5 \text{ Pa}$ and volume 0.5 m^3 so that its pressure becomes $8 \times 10^4 \text{ Pa}$. If $\gamma = 1.4$, find the new volume.
18. A Carnot engine works between temperatures 500 K and 300 K. Find (a) its efficiency and (b) the heat rejected per cycle if it absorbs 4000 J per cycle.

Section D — Long Answers ($2 \times 5 = 10$ marks)

19. Explain the four steps of a Carnot cycle and derive the efficiency of a Carnot engine, showing why no engine can be more efficient than the Carnot engine operating between the same temperatures.
20. Apply the first law of thermodynamics to isochoric, isobaric, isothermal and adiabatic processes, derive the work done in each, and show that an adiabatic process follows $pV^\gamma = \text{constant}$.

Answer Key (Marking Scheme)

- Q1 — (A) the same temperature. Q2 — (A) temperature measurement. Q3 — (A) their temperatures differ. Q4 — (A) Heat (Q).
- Q5 — (A) temperature. Q6 — (A) $P\Delta V$. Q7 — (A) Internal energy. Q8 — (A) conservation of energy.
- Q9 — Isothermal: process at constant temperature ($PV = \text{constant}$). Adiabatic: no heat exchange with the surroundings ($PV^\gamma = \text{constant}$).
- Q10 — No process can operate in cycles and convert all the heat absorbed from a single reservoir completely into work.
- Q11 — $W = nRT \ln(V_2/V_1) = 1 \times 8.31 \times 300 \times \ln 2 \approx 1729 \text{ J}$.
- Q12 — $\Delta U = Q - W = 400 - 400 = 0$ (cyclic process).
- Q13 — $R = C_p - C_v = 29 - 21 = 8 \text{ J/mol K}$.

Q14 — $W = P\Delta V = 4 \times 10^5 \times 3 = 1.2 \times 10^6 \text{ J}$.

Q15 — At constant pressure $Q_P = nC_P\Delta T = \Delta U + P\Delta V = nC_V\Delta T + nR\Delta T$ $C_P - C_V = R$.

Q16 — Carnot cycle: isothermal expansion, adiabatic expansion, isothermal compression, adiabatic compression. $\eta = 1 - Q_2/Q_1 = 1 - T_2/T_1$.

Q17 — $V_2 = V_1(P_1/P_2)^{1/\gamma} = 0.5 \times 2.5^{1/1.4} \approx 0.96 \text{ m}^3$.

Q18 — (a) $\eta = 1 - 300/500 = 40\%$; (b) $Q_2 = Q_1T_2/T_1 = 4000 \times 300/500 = 2400 \text{ J}$.

Q19 — Four reversible steps; heat Q_1 taken at T_1 , Q_2 rejected at T_2 ; efficiency $\eta = 1 - T_2/T_1$; the second law forbids any irreversible engine between the same temperatures from exceeding this.

Q20 — Isochoric: $W = 0$, $Q = \Delta U = nC_V\Delta T$. Isobaric: $W = P\Delta V$, $Q = nC_P\Delta T$. Isothermal: $\Delta U = 0$, $Q = W = nRT \ln(V_2/V_1)$. Adiabatic: $Q = 0$, $\Delta U = -W$, and $pV^\gamma = \text{constant}$ follows from $dU = -pdV$ with $U = nC_VT$.